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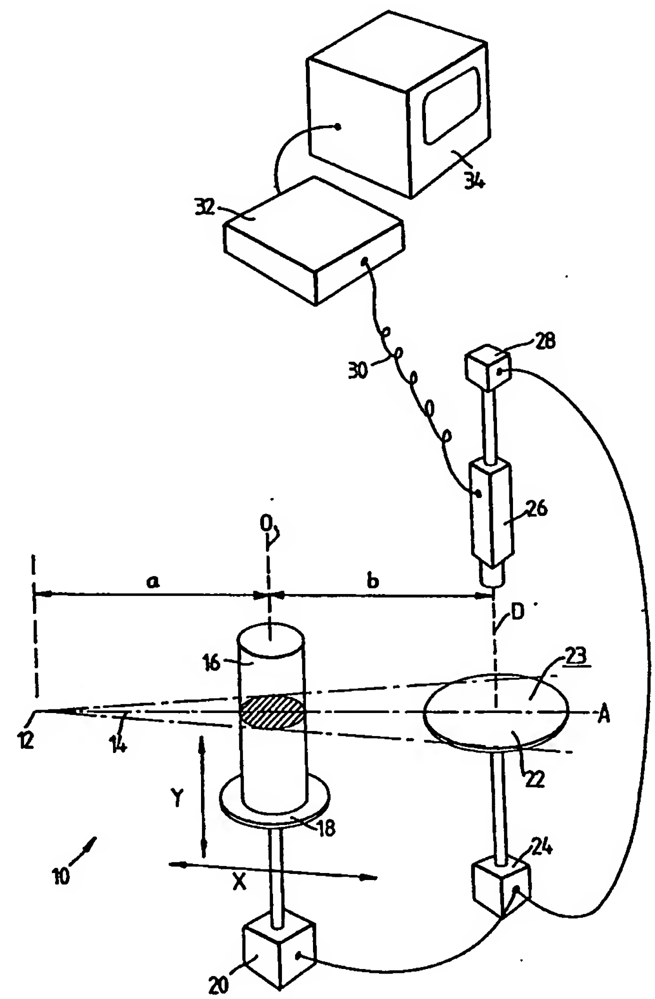
(54) Tomography

(57) In an apparatus for obtaining a sectional view of an object by radiography, the object (16) is supported near a fluorescent disc (22), the object and the disc being rotated about parallel axes (O, D) at the same rate, while being irradiated by a divergent beam (14) of penetrating radiation such as X-rays so that an image of the object is projected onto the disc. The image on the disc is viewed by a coaxial television camera (26) rotating at the same rate, and the average of successive images so produced is displayed by a monitor (34).



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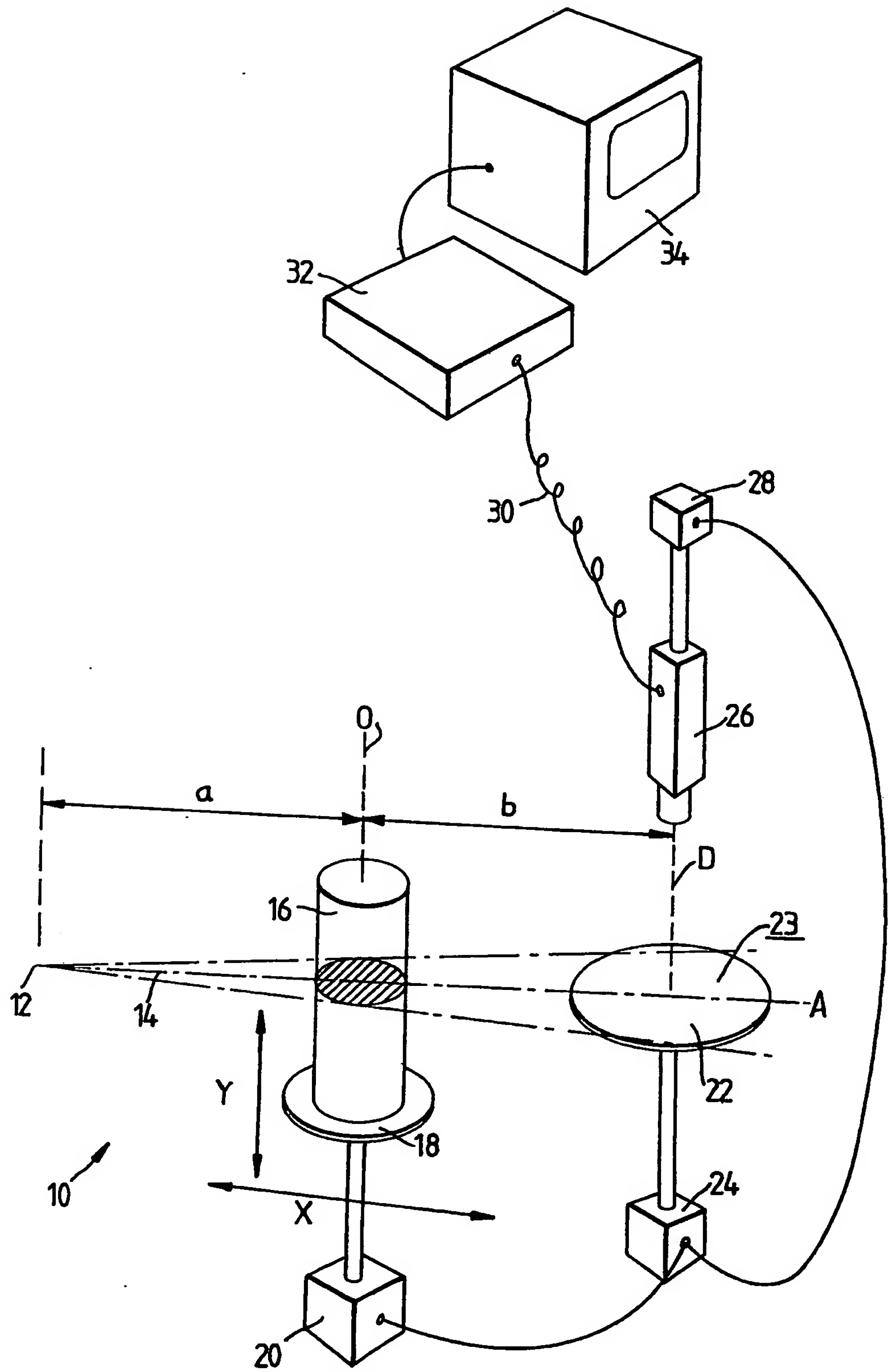

SPECIFICATION

Tomography

This invention relates to an apparatus and a method for performing tomography, that is for obtaining a sectional view of an object by radiography using a penetrating radiation such as X-radiation.

An apparatus for performing tomography is described in US Patent No. 2 196 618 (W.Watson) in which an X-ray source, an object support and a film support are arranged in alignment, the object support and the film support being rotated about parallel axes at the same rate during operation. An image is produced on the film corresponding to a section through the object on a plane parallel to that on which the film lies; the film (and so also the section) may be perpendicular to the axis of rotation, or parallel to it, or at any desired angle to the axis of rotation. At any one fixed position of the film and the object, features of the object both in and out of the desired section are projected onto the film, but as the film and object rotate those features lying in the desired plane generate a clear and distinct image, while any features out of that plane generate a blurr.

This technique has been found capable of providing tomographic images of high quality, but does not enable images to be obtained in real time.

According to the present invention there is provided an apparatus for performing tomography on an object, the apparatus comprising a fluorescent disc sensitive to penetrating radiation; a source of the radiation arranged such that the axis of a beam of the radiation therefrom passes, in operation, through the object and the disc in succession; a television camera arranged to view the disc, and means for integrating the images obtained by the camera; means for rotating the axis of the beam relative to the object about a first axis which intersects the axis of the beam, and means for rotating the camera synchronously with the relative rotation, about a second axis of rotation parallel to the first axis and which also intersects the axis of the beam.

In general the disc is also rotated synchronously with the TV camera and about the same axis of rotation; though if the axis of rotation of the camera is perpendicular to the plane of the disc the disc may alternatively remain stationary.

For tomography of a portable object, the apparatus includes a support means for the object, and the said relative rotation is brough about by rotating the support means about the first axis. For tomography of an immovable object the source, and the disc and camera, are arranged on opposite sides of the object and are rotated around the object so as to follow circular paths certred on the first axis; the camera (and if desired the disc) is simultaneously rotated about the second axis of rotation which intersects the beam and so also follows a circular path.

The integrating means may comprise a television monitor with a very long persistence screen, or it may comprise an image processing computer for averaging successive images obtained by the camera. An alternative way of performing the integration is to photograph the monitor using a long exposure whose duration is preferably the time for one revolution of the television camera.

The penetrating radiation may be X-rays or neutrons, and, at least for the former, the source is preferably a micro-focal source, with a focal spot of diameter about 15 micrometres or less. The distances between the source and the object and between the object and the disc are desirably variable so as to be able to provide a magnification of up to about twenty times. The intensity or penetrating power of the beam may be preset, or be regulated automatically during exposure.

Although an image produced on a fluorescent disc is generally more grainy than one produced on a photographic film, this is mitigated by the use of a microfocal source, as acceptable resolution can be achieved by using a magnified image.

The invention also provides a method for performing tomography on an object, the method comprising irradiating the object with a beam of penetrating radiation, and receiving the radiation on a fluorescent disc onto which an image of the object is projected, viewing the disc with a television camera and integrating over time the images obtained by the camera, whilst rotating the axis of the beam relative to the object about a first axis which intersects the axis of the beam, and synchronously rotating the camera about a second axis parallel to the first axis and which also intersects the axis of the beam.

The relative rotation may be brought about by rotating the object about the first axis.

The method is applicable to a wide range of materials and objects including metals, fibre-composite materials, wood, multi-strand cables, concrete, ceramics, and joints such as welds.

In a modification of the method, the camera is held stationary but the images produced by it are rotated electronically; this can be performed by an image-processing computer used to average successive images after rotation.

The invention will now be further described by way of example only and with reference to the accompanying drawing, which shows a diagrammatic perspective view of an apparatus for performing tomography. Referring to the drawing, the apparatus 10 comprises a microfocal X-ray source 12 with a focal diameter of ten micrometres and operating at 150 kV. When energised, the source 12 emits a divergent beam 14 of X-rays whose optical axis is marked A. An object 16 (shown as a cylinder) is supported on a rotary table 18 driven by an electric motor 20, and is rotated during operation about an axis of rotation, O, which intersects the optical axis A. The motor 20 and the support table 18 are supported on guides (not shown) so that they can, if desired, be slid parallel to the optical axis A (arrow X) or slid in the direction of the axis of rotation O (arrow Y).

To the side of the rotary table 18 remote from the source 12 is a circular disc 22 whose upper surface 23 is coated with a fluorescent layer of fine grain gadolinium oxysulphide. The disc 22 is rotatable about an axis D parallel to the axis of rotation O, the

axis D intersecting the optical axis A at the centre of the disc 22, the rotation being brought about any an electric motor 24. The disc 22 is planar, and is perpendicular to the axis of rotation D, and it is arranged so that the source 12 is a short distance above the plane of the disc 22.

A low-light television camera 26 is mounted above the disc 22 aligned with the axis D so as to view the disc 22, and is rotatable about the axis D by an electric motor 28. All three electric motors 20, 24 and 28 are synchronous motors, and they are interconnected so that when they are energised the support table 18, the disc 22 and the camera 26 rotate in the same direction and at the same speed. The camera 26 is connected by a long, flexible cable 30 to an image processor 32 linked to a television monitor 34.

In operation of the apparatus 10, the motor 20 (and the support table 18) is slid in the direction Y so that a view can be obtained of a desired section (shown hatched) through the object 16 - the section is always parallel to the plane of the disc 22, and its position is defined by the point at which the axes O and A intersect, which must lie in the section. The motors 20, 24 and 28 are energised so the object 16, the disc 22 and the camera 26 rotate. The X-ray source 12 is energised, and an image of the object 16 is projected on the disc 22. The camera 26 views the image on the fluorescent layer 23, and as the camera 26 and the disc 22 rotate the images are processed by the image processor 32 and displayed on the monitor 34; the displayed image is obtained by averaging successive images as detected by the camera 26, and so provides a clear image of only those features lying on the desired section of the object 16. If the object 16, and the disc 22 were stationary, features of the object 16 both in and out of the desired section would be projected onto the disc 22, but as they rotate the images of features outside the section move relative to the disc 22, and when the images are averaged such features produce only a blurr. Ideally an image of the desired section can be obtained in just one complete revolution, but the cable 30 is long enought to permit the camera 26 to make several revolutions.

Because the X-ray beam 14 diverges from a small source 12 the image is magnified, the magnification factor being equal to the ratio of the source-to-image distance a + b to the source-to-object distance a. In the apparatus 10 the source 12 and the disc 22 are at a fixed separation (typically 3 metres), and the magnification factor can be varied by sliding the motor 20 and the object support table and the object support table 18 in the direction of arrows X. The magnification factor can thus be chosen to have a value from just over one up to about twenty.

Although the upper surface 23 of the disc 22 has been described as being coated with gadolinium oxysulphide, it will be appreciated that any material which emits visible light when irradiated by X-rays may be used as an alternative, for example zinc sulphide or sodium iodide. Furthermore the penetrating radiation used might alternatively be a beam of neutrons, in which case it will be appreciated that the disc 22 would have to be coated with a layer of a material which emits light when irradiated by neutrons.

If the object 16 is of varying opacity to the radiation as it rotates (e.g. of non-symmetrical section), means may be provided to continuously adjust the intensity or penetrating power of the radiation in accordance with the opacity, so as to improve the contrast of fine details within the image.

Although in the apparatus described above synchronous rotation of the object 16, the disc 22 and the camera 26 is brought about by three electric motors 20, 24 and 28 it will be appreciated that the rotation may instead by brought about by a single motor and mechanical drives. It will also be appreciated that where, as in the embodiment shown, the disc is perpendicular to the axis of rotation D of the TV camera, there is no necessity to rotate the disc itself.

CLAIMS

1. An apparatus for performing tomography on an object, the apparatus comprising a fluorescent disc sensitive to penetrating radiation; a source of the radiation arranged such that the axis of abeam of the radiation therefrom passes, in operation, through the object and the disc in succession; a television camera arranged to view the disc, and means for integrating the images obtained by the camera; means for rotating the axis of the beam relative to the object about a first axis which intersects the axis of the beam, and means for rotating the camera synchronously with the relative rotation, about a second axis of rotation parallel to the first axis and which also intersects the axis of the beam.

2. An apparatus as claimed in Claim 1 including a support means for the object, and wherein the means for rotating the axis of the beam relative to the object comprises means for rotating the support means about the first axis of rotation.

3. An apparatus as claimed in Claim 1 or Claim 2 wherein the integrating means comprises a television screen with a very long persistence screen.

4. An apparatus as claimed in Claim 1 or Claim 2 wherein the integrating means comprises an image processing computer.

5. An apparatus as claimed in any one of the preceding Claims wherein the radiation is X-radiation, and the source is a micro-focal source with a focal spot of diameter about 15 micrometres or less.

6. An apparatus as claimed in Claim 5 wherein the ratio of the distances between the source and the object and between the source and the disc is variable so as to provide a variable degree of magnification.

7. An apparatus as claimed in Claim 5 or Claim 6 wherein the distances between the source and the object and between the source and the disc are such as to provide magnification of about twenty times.

8. An apparatus as claimed in any one of the preceding Claims including means for regulating the intensity of the beam during operation.

9. A method for performing tomography on an object the method comprising irradiating the object

with a beam of penetrating radiation, and receiving the radiation on a fluorescent disc onto which an image of the object is projected, viewing the disc with a television camera and integrating over time the images obtained by the camera, whilst rotating the axis of the beam relative to the object about a first axis which intersects the axis of the beam, and synchronously rotating the camera about a second axis parallel to the first axis and which also intersects the axis of the beam.

10. A method as claimed in Claim 9 wherein the relative rotation is brought about by rotating the object about the first axis of rotation.

11. A method as claimed in Claim 9 or Claim 10 wherein the beam is a divergent beam, so as to produce a magnified image.

12. A method as claimed in Claim 11 wherein the magnification is variable.

13. A method as claimed in Claim 11 wherein the magnification is about twenty times.

14. A method for performing tomography on an object the method comprising irradiating the object with a beam of penetrating radiation, and receiving the radiation on a fluorescent disc onto which an image of the object is projected, viewing the disc with a television camera and integrating over time the images obtained by the camera , whilst rotating the axis of the beam relative to the object about a first axis which intersects the axis of the beam, and synchronously rotating the camera image about a second axis parallel to the first axis and which also intersects the axis of the beam.

15. An apparatus for performing tomography on an object substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.

16. A method for performing tomography on an object substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.

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